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Field emissions of N₂O during biomass production may affect the sustainability of agro-biofuels

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Abstract

One way of reducing the emissions of fossil fuel-derived carbon dioxide (CO₂) is to replace fossil fuels with biofuels produced from agricultural biomasses or residuals. However, cultivation of soils results in emission of other greenhouse gasses (GHGs), especially nitrous oxide (N₂O). Previous studies on biofuel production systems showed that emissions of N₂O may counterbalance a substantial part of the global warming reduction, which is achieved by fossil fuel displacement. In the present study, we related measured field emissions of N₂O to the reduction in fossil fuel-derived CO₂, which was obtained when agricultural biomasses were used for biofuel production (Carter et al., in press). The analysis included five organically managed feedstocks (*viz.* dried straw of sole cropped rye, sole cropped vetch and intercropped rye-vetch, as well as fresh grass-clover and whole crop maize) and three scenarios for conversion of biomass into biofuel. The scenarios were i) bioethanol only, ii) biogas only and iii) co-production of bioethanol and biogas. In the last scenario, the biomass was first used for bioethanol fermentation and subsequently the effluent from this process was utilized for biogas production. The net GHG reduction was calculated as the avoided fossil fuel-derived CO₂, where the N₂O emission was subtracted. This value did not account for fossil fuel-derived CO₂ emissions from farm machinery and during conversion processes that turn biomass into biofuel. The greatest net GHG reduction, corresponding to 700-800 g CO₂ m⁻², was obtained by biogas production or co-production of bioethanol and biogas on either fresh grass-clover or whole crop maize. In contrast, biofuel production based on lignocellulosic crop residues (*i.e.* rye and vetch straw) provided considerably lower net GHG reductions (\leq 215 g CO₂ m⁻²), and even negative numbers sometimes. No GHG benefit was achieved by fertilizing the maize crop because the extra crop yield, and thereby increased biofuel production, was offset by enhanced N₂O emissions.

Keywords

bioethanol and/or biogas, carbon sequestration, digestate recycled as fertilizer, emission factor, fossil fuel displacement, grass-clover, methane, nitrous oxide, rye and vetch straw, whole crop maize

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References

Carter, M.S., Hauggaard-Nielsen, H., Heiske, S., Jensen, M., Thomsen, S.T., Schmidt, J.E., Johansen, A. and Ambus, P. (in press) Consequences of field N₂O emissions for the environmental sustainability of plant-based biofuels produced within an organic farming system. *Global Change Biology: Bioenergy*.